What is claimed is:

1. A method to calculate an element R(x,y) of a viewpoint-independent spatial covariance matrix of a given object in a database for infinitely dense sampling of illumination conditions, the method comprising:

calculating $E(u_x,u_y,c)$, an integral over all possible light directions, weighted by their respective intensities, according to the equation:

$$E(u_x,u_y,c) = \int_{n \in S^2} L(n)D(n,p,q)$$

where $n \in S^2$ is a particular direction on the unit sphere, S^2, where L is the light intensity and n is a normal vector on the unit sphere S^2, where u_x and u_y are the unit vectors of the special coordinate system defined by p and q, where p and q are vectors in which the x-axis is the bisector of the angle, 2θ, between them, where $p = (c,+s,0)$ and $q = (c,-s,0)$, where $c = \cos\theta$, $s = \sin\theta$, and (x,y) is the image point;

solving for the viewpoint-independent spatial covariance matrix R(x,y) according to the equation:

$$R(x,y) = \alpha(x)\alpha(y)E(u_x,u_y,c)$$

where $\alpha(x)$ is the intrinsic reflectance at the image point x and $\alpha(y)$ is the intrinsic reflectance at the image point y; and

tabulating and storing the result of said viewpoint-independent spatial covariance matrix R(x,y).

2. A method to calculate an element R(x,y) of a viewpoint-independent spatial covariance matrix of a given object where there is no preferred direction in the illumination, the method comprising:

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calculating E(c(p(x),q(y))), according to the equation:

$$E(c) = \int_{n \in S^2 \cap \{C(n,c)>0\}} c^2 n_x^2 - (1-c^2)n_y^2$$

where $n \in S^2$ is a particular direction on the unit sphere, S^2, where $C(n,c)$ is the joint-visibility condition, where n is the given direction, where p and q are vectors in which the x-axis is the bisector of the angle, 2θ, between them, where $p = (c,+s,0)$ and $q = (c,-s,0)$, where $c = \cos\theta$, $s = \sin\theta$, and (x,y) is the image point;

solving for the viewpoint-independent spatial covariance matrix R(x,y) according to the equation:
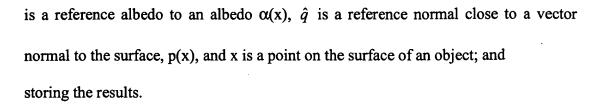
$$R(x,y) = \alpha(x)\alpha(y)E(c(p(x),q(y)))$$

where $\alpha(x)$ is the intrinsic reflectance at the image point x and $\alpha(y)$ is the intrinsic reflectance at the image point y; and

tabulating and storing the result of said viewpoint-independent spatial covariance matrix R(x,y).

3. The method of claim 2, comprising:

using the Monte Carlo procedure to evaluate the integral for E(c) in claim 2.

4. A method for finding a set of Q pairs of reference values for the albedo and normals, $\{(\hat{\alpha}_q, \hat{q})\}_{q \in Q}$, such that the perturbations are smallest for a given value of Q, the method comprising:

using vector quantization algorithms to cluster a set of vectors $\{(\alpha(x), p(x))\}_{x \in V}$ together in Q clusters;

finding the centroids $\{(\hat{\alpha}_q, \hat{q})\}_{q \in Q}$ of said clusters such that the average distance from the vectors to the nearest respective cluster-centroid, $q(x) \equiv q_x$, is minimal, where $\hat{\alpha}_q$

is a reference albedo to an albedo $\alpha(x)$, $\hat{q}$ is a reference normal close to a vector

normal to the surface, $p(x)$, and x is a point on the surface of an object; and

storing the results.

5.   The method of claim 4, comprising:

using a Linde-Buzo-Gray algorithm as said vector quantization algorithm.

6.   The method of claim 4, comprising:

using a Deterministic Annealing algorithm as said vector quantization algorithm.

7.   A method to generate a low-dimensional basis of the viewpoint-dependent illumination

subspace from the pre-computed viewpoint-independent hierarchy of eigen-surfaces, the

method comprising:

generating and diagonalizing said object's vector-quantized viewpoint-independent

covariance matrix R_Q;

determining the eigenbasis hierarchy defined on the surface of the object from the

results of R_Q, using the equation:

$$R(u,v) \approx \sum_{r=1}^{Q} \psi_r(u)\sigma_r^2\psi_r(v)$$

where Q is the desired complexity, where σ_r^2 is the non-increasing eigenspectrum of

the spatial and the temporal covariance matrices, where $\psi_r(u)$ and $\psi_r(v)$ are the

respective orthonormal eigenvectors of said spatial and temporal covariance matrices,

and (u,v) is a point on the surface of the object;

choosing a cutoff, N, such that the average residual signal power, trR_N, is between the

values of 0.1 - 10;

keeping only the first N eigensurfaces and storing the results for subsequent use;

warping said stored N eigensurfaces to a basis of the viewpoint-dependent illumination subspace at the viewpoint-dependent stage using the equation:

$$\widetilde{\psi}_r(x) = \widetilde{\psi}_r(x(u))$$

when a query at a particular viewpoint needs to be matched to the objects in said database; and

storing the results.

8. The method of claim 7, further comprising the step of finding M, the final dimensionality of the viewpoint-dependent eigen-subspace, the method comprising:

warping a viewpoint dependent, non-eigen-subspace of dimensionality N from a viewpoint independent eigen-subspace of dimensionality N; and

finding the leading M-dimensional viewpoint dependent eigen-subspace of the N-dimensional viewpoint dependent non-eigen-subspace resulting from said warp, according to the equation:

$$R(x,y) = \sum_{p=1}^{M} \overline{\psi}_p(x)\overline{\sigma}_p\overline{\psi}_p(y)$$

where

$$\overline{\sigma}_p\overline{\psi}_p(x) = \sum_{r=1}^{N} U_{pr}\widetilde{\psi}_r(x)$$

where $\overline{\sigma}_p$ and U_{pr} are determined by the eigenvalue decomposition of an N×N matrix B_{rs} where

$$B_{rs} = \sum_{x} \widetilde{\psi}_r(x)\sigma_r\sigma_s\widetilde{\psi}_s(x) = U_{pr}\sigma_p^2 U_{ps}$$

9. The method of claim 8, comprising:

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the final dimensionality of the viewpoint dependent subspace, M, having a value up to 20.

10. The method of claim 9, comprising:

the final dimensionality of the viewpoint dependent subspace, M, having a value between 4 and 9, inclusive.

11. The method of claim 8, comprising:

having the value of N not less than 2 times the value of M, and not more than 8 times the value of M.